

What is claimed is:

1. A singulation method comprising the steps of:
  - providing a generally planar circuit board substrate assembly having a longitudinal axis extending between a first end and a second end, the circuit board substrate assembly including a plurality of circuit board portions lying along the longitudinal axis, at least two of the plurality of circuit board portions separated by an opening and connected by interconnect material; and
    - removing at least a portion of the interconnect material along a first singulation axis and a second singulation axis extending substantially parallel to the longitudinal axis to singulate at least two circuit board portions, the first singulation axis and the second singulation axis intersecting with respective first and second portions of the opening.
- 15 2. The method of claim 1, wherein the step of removing interconnect material along the first singulation axis and the second singulation axis includes moving a singulation tool along the first singulation axis and the second singulation axis.
- 20 3. The method of claim 2, wherein the step of moving a singulation tool along the first singulation axis and the second singulation axis includes moving a routing tool along the first singulation axis and the second singulation axis.
4. The method of claim 1, wherein the opening is a single slot extending generally perpendicular to the longitudinal axis between adjacent circuit board portions.
- 25 5. The method of claim 1, wherein each of the plurality of circuit board portions is separated from another of the plurality of circuit board portions by an opening, the first singulation axis and the second singulation axis intersecting respective first and second

portions of each of the openings such that when the interconnect material is removed each of the circuit board portions is singulated from the other circuit board portions.

6. The method of claim 5, wherein each of the openings is a single slot extending generally perpendicular to the longitudinal axis between adjacent circuit portions, the first and second portions of each opening being at opposing ends of the slot.

7. A singulation method comprising the steps of:

providing a circuit board substrate assembly having a longitudinal axis extending between a first end and a second end of the circuit board substrate assembly, the circuit board substrate assembly including a plurality of openings positioned along the longitudinal axis, each of the plurality of openings separating two circuit forming regions of a plurality of circuit forming regions connected by interconnect material;

forming one or more circuit portions in one or more of the circuit forming regions; and

removing at least a portion of the interconnect material along a first singulation axis and a second singulation axis extending substantially parallel to the longitudinal axis, the first singulation axis and the second singulation axis intersecting with respective first and second open portions of each of the openings such that when the material is removed each of the plurality of circuit forming regions are singulated.

8. The method of claim 7, wherein the step of removing material along the first and the second singulation axis includes moving a singulation tool along the first and the second singulation axis.

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9. The method of claim 8, wherein the step of moving a singulation tool along the first and the second singulation axis includes moving a routing tool along the first and the second singulation axis.

10. The method of claim 7, wherein the opening is a single slot extending generally perpendicular to the longitudinal axis between adjacent circuit forming regions.

11. The method of claim 7, wherein a plurality of the circuit board substrate assemblies having one or more circuits formed thereon are stacked, removal of interconnect material being simultaneously removed from each of the circuit board substrate assemblies.

12. A singulation method comprising the steps of:

10 providing an elongate circuit board substrate assembly having a longitudinal axis extending along a length of the circuit board substrate assembly between a first end and a second end thereof, the circuit board substrate assembly further having a first edge and a second edge extending along the length of the circuit board substrate assembly between the first and second end;

15 providing a plurality of formed circuit portions along the longitudinal axis of the elongate circuit board substrate assembly, each of the plurality of formed circuit portions having a perimeter located at least a minimum distance from each of the first edge and second edge of the circuit board substrate assembly, each pair of adjacent formed circuit portions of the plurality of formed circuit portions being separated by an opening, the opening extending between a position located less than a maximum distance from each of the first edge and second edge of the circuit board substrate assembly, the minimum distance being greater than the maximum distance; and

20 removing interconnect material along a first singulation axis and a second singulation axis at each respective first and second edges of the circuit board substrate assembly extending substantially parallel to the longitudinal axis, the first singulation axis and the second singulation axis intersecting with first and second open portions of each of the openings such that when the interconnect material is removed the plurality of formed circuit portions are singulated.

13. The method of claim 12, wherein the step of removing material along the first singulation axis and the second singulation axis includes moving a singulation tool along the first singulation axis and the second singulation axis.

5 14. The method of claim 13, wherein the step of moving a singulation tool along the first singulation axis and the second singulation axis includes moving a routing tool along the first singulation axis and the second singulation axis.

10 15. The method of claim 12, wherein the circuit board substrate assembly is of a generally rectangular configuration and each opening is a single slot extending generally perpendicular to the longitudinal axis between adjacent formed circuit portions.

15 16. A singulation method comprising the steps of:  
providing a circuit board substrate assembly including a matrix of circuit board portions, the matrix of circuit board portions including two or more rows of circuit board portions, each row of circuit board portions formed along a corresponding longitudinal axis extending between a first end and a second end of the circuit board substrate assembly, each of the circuit board portions of the plurality of circuit board portions lying along each of the two or more rows being separated from an adjacent circuit board portion in the same row by an opening; and  
20 moving a singulation tool along a plurality of singulation axes extending substantially parallel to one another and parallel to the corresponding longitudinal axis of each row of circuit portions to singulate the matrix of circuit portions, the plurality of singulation axes including at least one singulation axis between adjacent rows of circuit board portions which intersects with a portion of one or more openings separating the plurality of circuit board portions lying along each of the adjacent rows.

25 17. A circuit board substrate assembly comprising:

a generally planar circuit board substrate material having a longitudinal axis extending along a length of the substrate material between a first end and a second end thereof, the circuit board substrate material further having a first edge and a second edge extending along the length of the circuit board substrate material between the first end and the second end; and

5 a plurality of openings defined in the substrate material, each opening extending between a first distance from the first edge of the circuit board substrate and a second distance from the second edge of the circuit board substrate, each opening separating adjacent circuit forming regions lying along the longitudinal axis, and further wherein each opening has a first and second opposing end portion with the first end portions of each opening lying along a first singulation axis of the substrate material parallel to the longitudinal axis and the second end portions of each opening lying along a second singulation axis of the substrate material parallel to the longitudinal axis.

10 15 18. The assembly of claim 17, wherein the circuit board substrate material is of a generally rectangular configuration and each opening is a single slot extending generally perpendicular to the longitudinal axis between the adjacent circuit forming regions.

20 19. The assembly of claim 17, further comprising one or more circuits formed in the circuit forming regions of the substrate material resulting in a plurality of individual circuit board portions wherein a perimeter of each of the plurality of individual circuit board portions located at least a minimum distance from each of the first and second edges of the circuit board substrate material, the minimum distance being greater than the first and second distances.

25 20. The assembly of claim 19, wherein one or more circuits include ball grid array configurations.

21. The assembly of claim 19, wherein one or more circuits include surface mount component configurations.

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Sub B1

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Sub C

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Sub D

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Sub E

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Sub F

22. A circuit board substrate assembly comprising a substrate material having first and second opposed edges, the substrate material comprising:  
a plurality of circuit forming regions comprising at least one pair of adjacent circuit forming regions;  
a first interconnection region and a second interconnection region, wherein the first interconnection region extends along the first edge and is located between the first edge and the plurality of circuit forming regions, wherein the second interconnection region extends along the second edge and is located between the second edge and the plurality of circuit forming regions; and  
10 at least one opening defined in the substrate material between each pair of adjacent circuit forming regions, wherein the at least one opening extends into at least portions of both the first interconnection region and second interconnection region.

23. The assembly of claim 22, wherein the substrate material further comprises a first end and a second end, wherein the plurality of circuit forming regions lie along a length of the substrate material between the first end and the second end, the length being defined along a longitudinal axis.

24. The assembly of claim 23, wherein both the first edge and second edge of the substrate material are substantially parallel to the longitudinal axis.

25. The assembly of claim 23, wherein the at least one opening comprises a first and second opposing end portion with the first end portion thereof lying along a first singulation axis of the substrate material parallel to the longitudinal axis and the second end portion of the at least one opening lying along a second singulation axis of the substrate material parallel to the longitudinal axis.

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26. The assembly of claim 23, wherein the at least one opening is a single slot extending generally orthogonal to the longitudinal axis.

5 27. The assembly of claim 23, further comprising one or more circuits formed in the circuit forming regions of the substrate material resulting in a plurality of individual circuit board portions, wherein at least one of the plurality of individual circuit board portions has a length orthogonal to the longitudinal axis.

28. The assembly of claim 27, wherein the at least one opening has a length that is orthogonal to the longitudinal axis, and further wherein the length of the at least one opening is greater than the length of the at least one of the plurality of individual circuit board portions.

15 29. The assembly of claim 27, wherein the one or more circuits comprise ball grid array configurations.

30. The assembly of claim 27, wherein the one or more circuits comprise surface mount component configurations.

20 31. The assembly of claim 22, wherein the at least one opening comprises a slot extending into at least portions of the first and second interconnection regions.

25 32. The assembly of claim 22, wherein the at least one opening between each pair of adjacent circuit forming regions is configured such that the plurality of circuit forming regions are separable by using a material removal tool operable to move along one or more parallel singulation axes to remove at least portions of the first and second interconnection regions.

33. A circuit board substrate assembly comprising a substrate material, wherein the substrate material comprises a plurality of rows of circuit forming regions lying along a length of the substrate material, wherein each row comprises at least one pair of adjacent circuit forming regions, wherein a singulation axis is defined between each pair of adjacent rows, wherein at least one pair of adjacent circuit forming regions in at least one row is separated by at least one opening defined in the substrate material that intersects with a singulation axis defined between the at least one row and an adjacent row, and that further intersects with a singulation axis defined between the at least one row and another adjacent row.

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34. The assembly of claim 33, wherein the substrate material further comprises a plurality of columns of circuit forming regions.

35. The assembly of claim 33, wherein the substrate material further comprises:  
15 first and second opposed edges; and  
a first interconnection region and a second interconnection region, wherein the first interconnection region extends along the first edge and is located between the first edge and a first end row of the plurality of rows of circuit forming regions, wherein the second interconnection region extends along the second edge and is located between the second edge and a second end row of the plurality of rows of circuit forming regions, and further wherein one or more openings defined in the substrate material separating adjacent circuit forming regions in the first and second rows extend into at least one or more portions of the first interconnection region and second interconnection region, respectively.

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25 36. The assembly of claim 33, wherein the plurality of rows of circuit forming regions lie along a length of the substrate material, the length being defined along a longitudinal axis.

37. The assembly of claim 36, wherein the substrate material further comprises a first edge and a second edge, wherein both the first edge and a second edge of the substrate material are substantially parallel to the longitudinal axis.

5 38. The assembly of claim 36, wherein the at least one opening has a first and second opposing end portion, the first end portion of each opening lying along a first singulation axis of the substrate material parallel to the longitudinal axis and the second end portion of the at least one opening lying along a second singulation axis of the substrate material parallel to the longitudinal axis.

10 39. The assembly of claim 38, wherein the at least one opening is a single slot extending generally perpendicular to the longitudinal axis.

15 40. The assembly of claim 36, further comprising one or more circuits formed in the adjacent circuit forming regions of the substrate material resulting in adjacent individual circuit board portions, wherein the adjacent individual circuit board portions have a length orthogonal to the longitudinal axis.

20 41. The assembly of claim 40, wherein the at least one opening separating the adjacent individual circuit board portions has a length that is orthogonal to the longitudinal axis, and further wherein the length of the at least one opening is greater than the length of the adjacent individual circuit board portions.

25 42. The assembly of claim 40, wherein the one or more circuits comprise ball grid array configurations.

43. The assembly of claim 40, wherein the one or more circuits comprise surface mount component configurations.

44. The assembly of claim 36, wherein the at least one opening comprises a slot orthogonal to the longitudinal axis.

45. The assembly of claim 36, wherein the at least one opening is configured such 5 that the plurality of circuit forming regions are separable by using a material removal tool operable to move along one or more singulation axes.

46. The assembly of claim 45, wherein the material removal tool comprises a routing tool.

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47. A circuit board substrate assembly comprising:  
a substrate material having a length defined along a longitudinal axis;  
a plurality of rows of circuit forming regions of the substrate material aligned parallel to the longitudinal axis;  
one or more circuits formed in the circuit forming regions resulting in rows of 15 individual circuit portions lying along the length of the substrate material parallel to the longitudinal axis, wherein each individual circuit portion comprises a first end portion and a second end portion, and further wherein each individual circuit portion in a row is separated from each adjacent individual circuit portion in the row by an opening;  
a plurality of interconnection regions extending along the length of the substrate material parallel to the longitudinal axis, wherein the first and second end portions of each individual circuit portion are adjacent to an interconnection region; and  
20 a singulation axis defined along the length of the substrate material within each of the plurality of interconnection regions, wherein each singulation axis is parallel to the longitudinal axis, wherein the opening separating each individual circuit portion in a row from each adjacent circuit portion in the row extends into an 25

interconnection region adjacent the first end portion of the individual circuit portion and intersects with a singulation axis lying within such interconnection region, and further wherein such opening extends into an interconnection region adjacent the second end portion of the individual circuit portion and intersects a singulation axis lying within such interconnection region.

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48. The assembly of claim 47, wherein the opening is a single slot extending generally orthogonal to the longitudinal axis.

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49. The assembly of claim 47, wherein at least one of the individual circuit board portions has a length orthogonal to the longitudinal axis extending between the first end portion and second end portion thereof.

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50. The assembly of claim 49, wherein the opening has a length that is orthogonal to the longitudinal axis, and further wherein the length of the opening is greater than the length of the at least one individual circuit board portion.

51. The assembly of claim 47, wherein the opening comprises a slot.

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52. The assembly of claim 47, wherein the opening is configured such that the individual circuit board portions are separable by using a material removal tool operable to move along one or more of the singulation axes defined along the length of the substrate material.

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53. The assembly of claim 47, wherein one or more of the individual circuit portions comprise ball grid array configurations.

54. The assembly of claim 47, wherein one or more of the individual circuit portions comprise surface mount component configurations.

55. A circuit board substrate assembly comprising:  
5 a substrate material having a length defined along a longitudinal axis;  
a plurality of rows of circuit forming regions of the substrate material aligned parallel to the longitudinal axis;  
one or more circuits formed in the circuit forming regions resulting in a plurality of rows of individual circuit portions lying along the length of the substrate 10 material parallel to the longitudinal axis, wherein each individual circuit portion in a row is separated from each adjacent individual circuit portion in the row by an opening;  
15 at least one row of the plurality of rows of individual circuit portions being adjacent a first interconnection region and a second interconnection region, wherein the first interconnection region and the second interconnection region lie along the length of the substrate material parallel to the longitudinal axis, wherein the first interconnection region is located between the at least one row of individual circuit portions and an adjacent row of individual circuit portions, and further wherein the second interconnection region is located between the at least one row of individual 20 circuit portions and another adjacent row of individual circuit portions; and  
25 a first singulation axis and a second singulation axis, wherein the first singulation axis and the second singulation axis lie along the length of the substrate material parallel to the longitudinal axis, wherein the first singulation axis is defined in the first interconnection region, wherein the second singulation axis is defined in the second interconnection region, wherein the opening separating each individual circuit portion of the at least one row from each adjacent circuit portions in the at least one row extends into the first interconnection region and the second interconnection region, and further wherein the opening intersects the first singulation

axis and the second singulation axis.

56. The assembly of claim 55, wherein the opening is a single slot extending generally orthogonal to the longitudinal axis.

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57. The assembly of claim 55, wherein at least one of the individual circuit portions has a length orthogonal to the longitudinal axis.

10 58. The assembly of claim 57, wherein the opening has a length that is orthogonal to the longitudinal axis, and further wherein the length of the opening is greater than the length of the at least one individual circuit portion.

59. The assembly of claim 55, wherein the opening comprises a slot.

15 60. The assembly of claim 55, wherein the opening is configured such that the individual circuit portions are separable by using a material removal tool operable to move along one or more of the singulation axes.

20 61. The assembly of claim 55, wherein one or more of the individual circuit portions comprise ball grid array configurations.

62. The assembly of claim 55, wherein one or more of the individual circuit portions comprise surface mount component configurations.

25 63. A singulation method comprising:  
providing a circuit board substrate assembly comprising a substrate material having first and second opposed edges, the substrate material comprising:  
a plurality of circuit forming regions comprising at least one pair of

adjacent circuit forming regions;

5                   a first interconnection region and a second interconnection region, wherein the first interconnection region extends along the first edge and is located between the first edge and the plurality of circuit forming regions, wherein the second interconnection region extends along the second edge and is located between the second edge and the plurality of circuit forming regions; and

10                  at least one opening defined in the substrate material between each pair of adjacent circuit forming regions, wherein the at least one opening extends into at least portions of both the first interconnection region and second interconnection region.

15                  removing at least a portion of the first and second interconnection regions along a respective first and second singulation axis defined therein parallel to one another to singulate at least two circuit forming regions of the plurality of circuit forming regions, the first singulation axis and the second singulation axis intersecting with the at least one opening defined between each pair of adjacent circuit forming regions.

20                  64.        The method of claim 63, wherein removing at least a portion of the first and second interconnection regions comprises moving a singulation tool along the first singulation axis and the second singulation axis.

25                  65.        The method of claim 64, wherein moving a singulation tool along the first singulation axis and the second singulation axis comprises moving a routing tool along the first singulation axis and the second singulation axis.

66. A singulation method comprising:  
providing a circuit board substrate assembly comprising a substrate material, wherein the substrate material comprises a plurality of rows of circuit forming regions lying along a length of the substrate material, wherein each row comprises at least one pair of adjacent circuit forming regions, wherein a singulation axis is defined between each pair of adjacent rows, wherein at least one pair of adjacent circuit forming regions in at least one row is separated by at least one opening defined in the substrate material that intersects with a singulation axis defined between the at least one row and an adjacent row, and that further intersects with a singulation axis defined between the at least one row and another adjacent row; and  
removing at least a portion of the substrate material along each singulation axes to singulate the at least one pair of adjacent circuit forming regions of the at least one row of circuit forming regions.

67. The method of claim 66, wherein removing at least a portion of the substrate material comprises moving a singulation tool along each of the singulation axes.

68. The method of claim 67, wherein moving a singulation tool along each of the singulation axes comprises moving a routing tool along each of the singulation axes.

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